



Human Exploration and Operations Committee Status

Ken Bowersox
Committee Chair
December 2nd, 2015



NAC HEO Committee Members



- Ms. Bartell, Shannon
- Mr. Bowersox, Ken, ***Chair***
- Ms. Budden, Nancy Ann
- Dr. Chiao, Leroy
- Dr Condon, Stephen "Pat"
- Mr. Cuzzupoli, Joseph W.
- Mr. Holloway, Tom
- Mr. Lon Levin
- Dr. Longenecker, David E.
- Mr. Lopez-Alegria, Michael
- Mr. Malow, Richard N.
- Mr. Odom, Jim (James)
- Mr. Sieck, Robert
- Mr. Voss, James

Major Events Since Last NAC Meeting



- ISS passed 15 years of operations with crew
- One Year Crew – past 75% complete
- ISS EVAs
- Successful HTV-5 cargo mission
- Successful Progress cargo missions 60P and 61P
- Soyuz 44 launch and 42 landing
- Continued ISS science for Increment 44 and 45
- SLS CDR
- Contracts for first commercial crew missions to Boeing and SpaceX
- Release of Journey to Mars – Pioneering Space

NAC HEO Meeting Summary November, 2015



NAC HEO Committee Meeting

Wednesday, November 4th, 2015

- Human Exploration and Operations Status
- Exploration Systems Status
- Advanced Exploration Systems Status

Thursday, November 5th, 2015

- HEOMD Status
- ISS Status
- Commercial Crew Status
- Commercial Crew Contractor Briefings
- Committee Discussion and Deliberation

International Space Station Status



Sam Scimemi
Director, ISS
NASA HQ
HEO NAC
November 2015



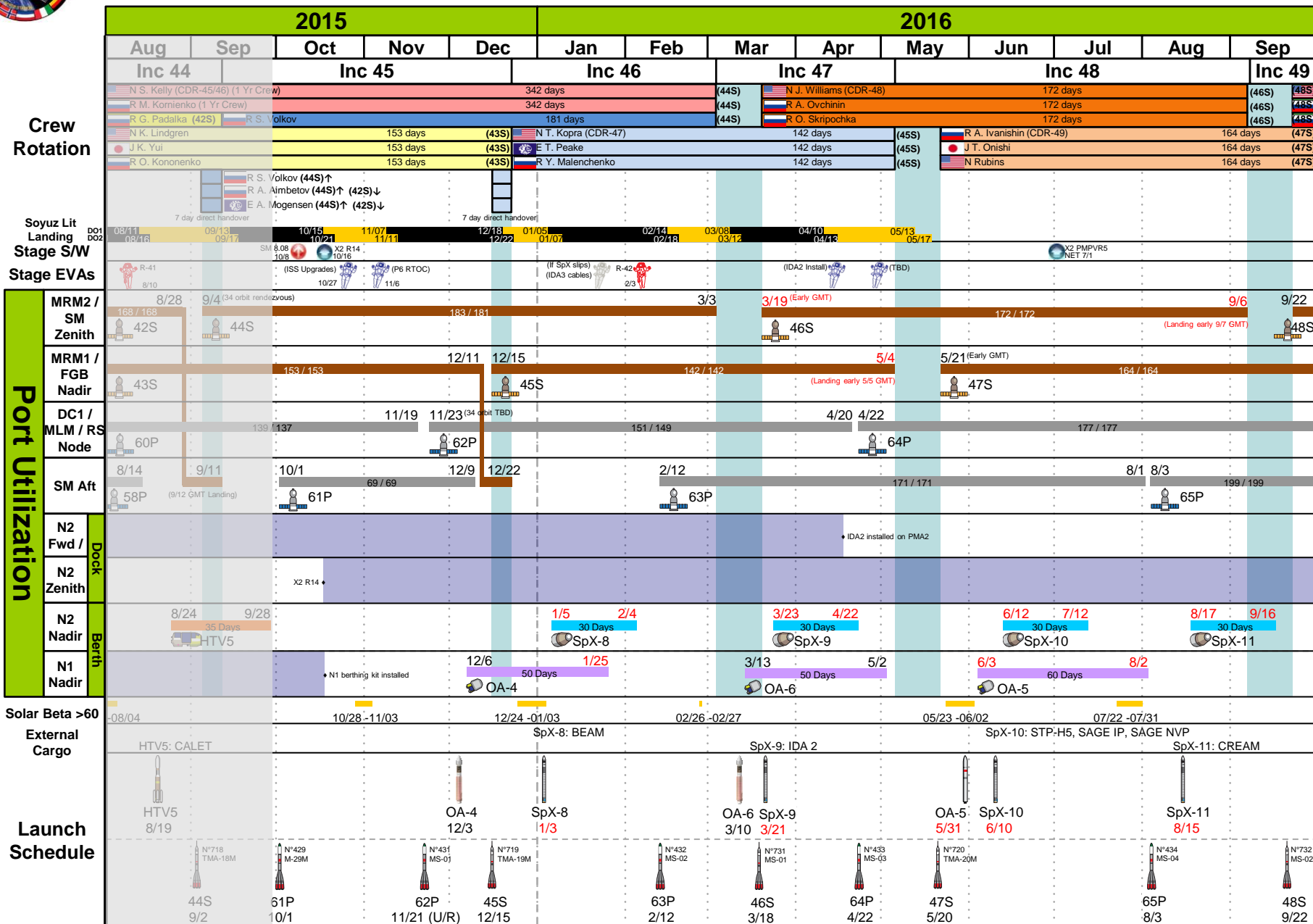
For current baseline refer to
SSP 54100 Multi-Increment
Planning Document (MIPD)

ISS Flight Plan

Flight Planning Integration Panel (FPIP)

(Pre-decisional, For Internal Use, For Reference Only)

NASA: OC4/John Coggeshall
MAPI: OP/Randy Morgan
Chart Updated: October 26, 2015





Increment 45 Overview: Crew



42S Dock 3/28/15
44S Dock 9/2/15
44S Undock 3/3/16



Scott Kelly
CDR (U) – 42S↑ / 44S↓



Mikhail Kornienko
FE (R) – 42S↑ / 44S↓



Sergei Volkov
FE (R) – 44S

44S Undock 3/3/16



Oleg Kononenko
FE (R) – 43S

43S Dock 7/23/15
43S Undock 12/22/15



Kimiya Yui
FE (J) – 43S



Kjell Lindgren
FE (U) – 43S



Total ISS Consumables Status



	T1: Current Capability		T2: Current Capability + 62P + OA-4	
Consumable – based on current, ISS system status	Date to Reserve Level	Date to zero supplies	Date to Reserve Level	Date to zero supplies
Food – 100%	February 09, 2016	April 02, 2016	May 28, 2016	July 15, 2016
KTO	February 07, 2016	March 31, 2016	June 26, 2016	August 10, 2016
Filter Inserts	October 28, 2016	December 19, 2016	December 19, 2016	> December 31, 2016
Toilet (ACY) Inserts	May 28, 2016	July 12, 2016	June 22, 2016	August 06, 2016
EDV + TUBSS (UPA Operable)	June 28, 2016	October 07, 2016	September 30, 2016	> December 31, 2016
Pre-Treat Tank	March 23, 2016	May 11, 2016	August 14, 2016	October 06, 2016
Water (Nominal Usage)	June 02, 2016	September 11, 2016	July 20, 2016	November 07, 2016
Consumable - based on system failure				
EDV + TUBSS (UPA Failed)	March 13, 2016	May 02, 2016	May 04, 2016	June 27, 2016
Water, if no WPA (Ag & Iodinated)	March 05, 2016	May 23, 2016	April 12, 2016	June 24, 2016
O ₂ if Elektron supporting 3 crew & no OGA	November 28, 2015	March 31, 2016	December 26, 2015	May 21, 2016
O ₂ if neither Elektron or OGA	November 09, 2015	January 02, 2016	November 09, 2015	January 20, 2016
LiOH (CDRAs and Vozdukh off)	~0 Days	~14 Days	~0 Days	~14 Days



HTV5 Mission Status



➤ Mission Planning

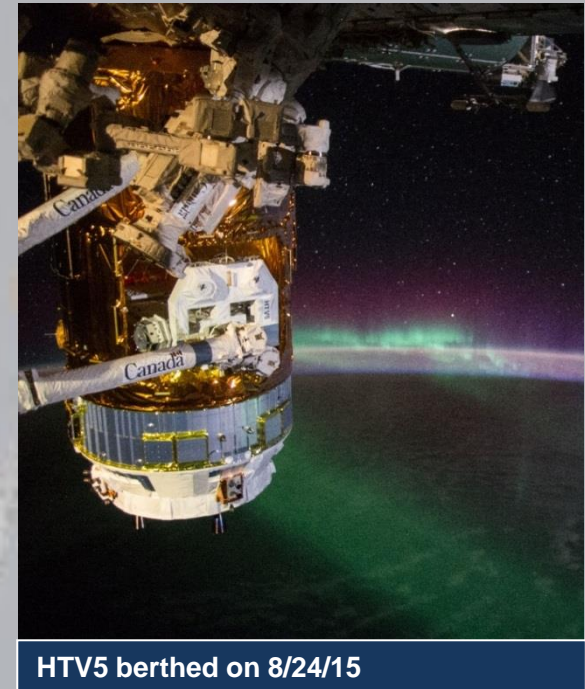
- Stage Operations Readiness Review (SORR) completed on 7/27/15
- Successful launch on 8/19/15 and berthing on 8/24/15
- No major issues tracked during mission
- Successful departure on 9/28/15

➤ Cargo

- Pressurized cargo included Node 1 galley rack, MSPR-2 (JAXA rack), 30 Contingency Water Container – Iodine (CWC-I), and additional soft-stow cargo
- MPSR 2 was removed from HTV and installed in JEM in Aug
- Late load shipments #1 and #2 arrives at TNSC on 7/27/15 and 7/30/15 (NASA 992)
- Outstanding coordination post SpaceX-7 failure to adjust and add capability (MPSR front rack)
- Late load #1 and #2 completed on 8/13/15
- Vehicle launched ~ 8000 lbs pressurized, 1450 lbs external
- Trash Removed : 4,350 pounds

➤ External Cargo

- CALorimetric Electron Telescope (CALET) which will investigate the high energy universe was removed from the HTV5 Exposed Pallet (EP) and installed to ISS
- MCE, SMILES and STP-H4 experiments were installed on EP for disposal; EP was returned to HTV5 on 9/15/15



HTV5 berthed on 8/24/15



OA-4 (Orb-4) Mission Status



➤ Mission Planning

- Orbital has contracted with United Launch Alliance (ULA) for an Atlas V launch of Cygnus
- First use of Atlas V401 with the Cygnus spacecraft
- Cargo Integration Review (CIR) was conducted on 7/29/15
- Safety Review Panel (SRP) TIMs on 8/5/15 and 9/15/15
- Chief Engineer Readiness Review was completed on 9/1/15
- SRP Phase 3 is planned for completion on 10/13/15

➤ Pressurized Cargo complement

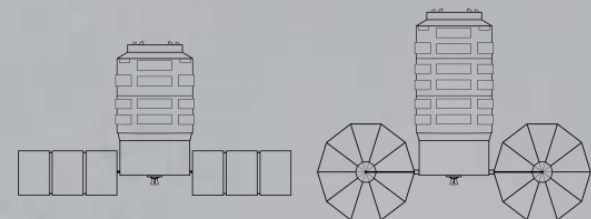
- NASA delivered ISS cargo manifest in June
- Planned Upmass : 7,730 pounds

➤ Cygnus Status

- First enhanced Cygnus with a longer Pressurized Cargo Module (PCM) and lightweight solar arrays
- Service Module (SM) will accommodate changes to the TriDAR/LIDAR configuration
- PCM completed FE1410 testing at the Cape on 8/20/15
- SM completed Final Integrated Systems Test (FIST) and scheduled to arrive at the Cape on 10/15/15
- Initial cargo arrival is planned for 10/16/15

➤ Atlas V 401

- Payload Adapter has been manufactured and is ready for integration
- Booster ship to CCAFS is planned for 10/30/15





SpaceX-8 Mission Status



➤ Mission Planning

- Cargo Integration Review (CIR) Part 1 completed on 5/28/15 with Part 2 planned for Oct
- Safety Review Panel (SRP) Phase 3 review is planned to be complete by 10/7/15
- Post Qualification Review (PQR) is planned for Nov
- Stage Operations Readiness Review (SORR) is planned for Dec

➤ Pressurized Cargo

- 1 Animal Enclosure Module-Transporter (AEM-T), 3 Polars (2 powered), and a NORS O2 Tank
- Planned Upmass : 3,810 pounds. Planned Return : 4,100 pounds

➤ External Cargo

- Bigelow Expandable Activity Module (BEAM) arrived at KSC on 7/23/15 and is dwelling in the SSPF until SpX is ready to integrate

➤ Dragon Status

- Capsule and trunk stacking for integrated checkouts at Hawthorne was completed on 7/27/15
- Final hatch blowdown and Acceptance Test Procedure (ATP) was completed on 8/25/15
- Vehicle in the Loop (VITL) and polarity testing was completed on 8/31/15
- Trunk and capsule are planned to be shipped by 10/9/15

➤ Falcon 9 Status

- SpX-8 will be first CRS Falcon flight with full thrust capability (2nd or 3rd Falcon flight with full thrust)
- Interstage in final assembly preparing for Stage 1 mate
- M1D qualification completion is planned for Oct with MVac qualification planned for Nov
- Stage 1 and 2 are planned to ship to TX by Nov for ATP



62P Progress-MS



- 62P is the first Progress MS vehicle
 - A number of updates to the Progress included in this version of the vehicle
 - MMOD shielding modified on the Orbital compartment (matches Soyuz vehicle updates)
 - Utilizes Kurs-NA rendezvous system instead of Kurs-A
 - GLONASS/GPS satellite navigation system added and previous orbital navigation hardware
 - Kvant radio replaced with S-band satellite communication system
- First Progress flight on Soyuz 2.1A booster since 59P accident
 - Russian specialists conducted coupled loads analysis with the Progress updates and the Soyuz 2.1A Booster
 - NASA has requested Russian specialist to present special topic from this analysis at upcoming reviews
 - NASA has requested a special topic on this at the Vehicle Assessment Review, SORR and FRR.
- Next Steps
 - 62P Vehicle Assessment Review – 10-15-15
 - 62P SORR – under review
 - 62P FRR – under review

HSF Transition from ISS to cis-lunar space and ISS Status



Sam Scimemi

**Director, International Space Station
NASA Headquarters**

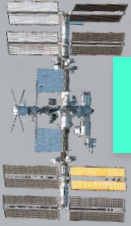
**HEOMD NAC
November 4, 2015**



Transitioning HSF from ISS to Cis-Lunar Space (Earth Reliant to the Proving Ground)



Earth Reliant



Long Duration Human Health & Habitation Research and Demonstrations

* Currently building a plan to demonstration on ISS the Mars habitation systems.

Knowledge & Capabilities

Goal at the end of the
2020s: Mars ready -
One year crewed
mission(s) in cis-lunar
space

Proving Ground

Short Duration Habitation & Transportation system validation

Long duration human health & habitation Validation for Mars transit

Knowledge & Capabilities

Learning how to be Earth Independent

- SLS/Orion performance validation
- Crew health and performance research and validation
- Habitation systems performance validation including EVA
- Radiation shielding characterization and validation
- Guidance and navigation in deep space
- Prox ops and docking in deep space
- Breaking the logistics chain
- Reduced reliance on the ground control
- Validating other spacecraft system validation (power, propulsion, communications, etc.)

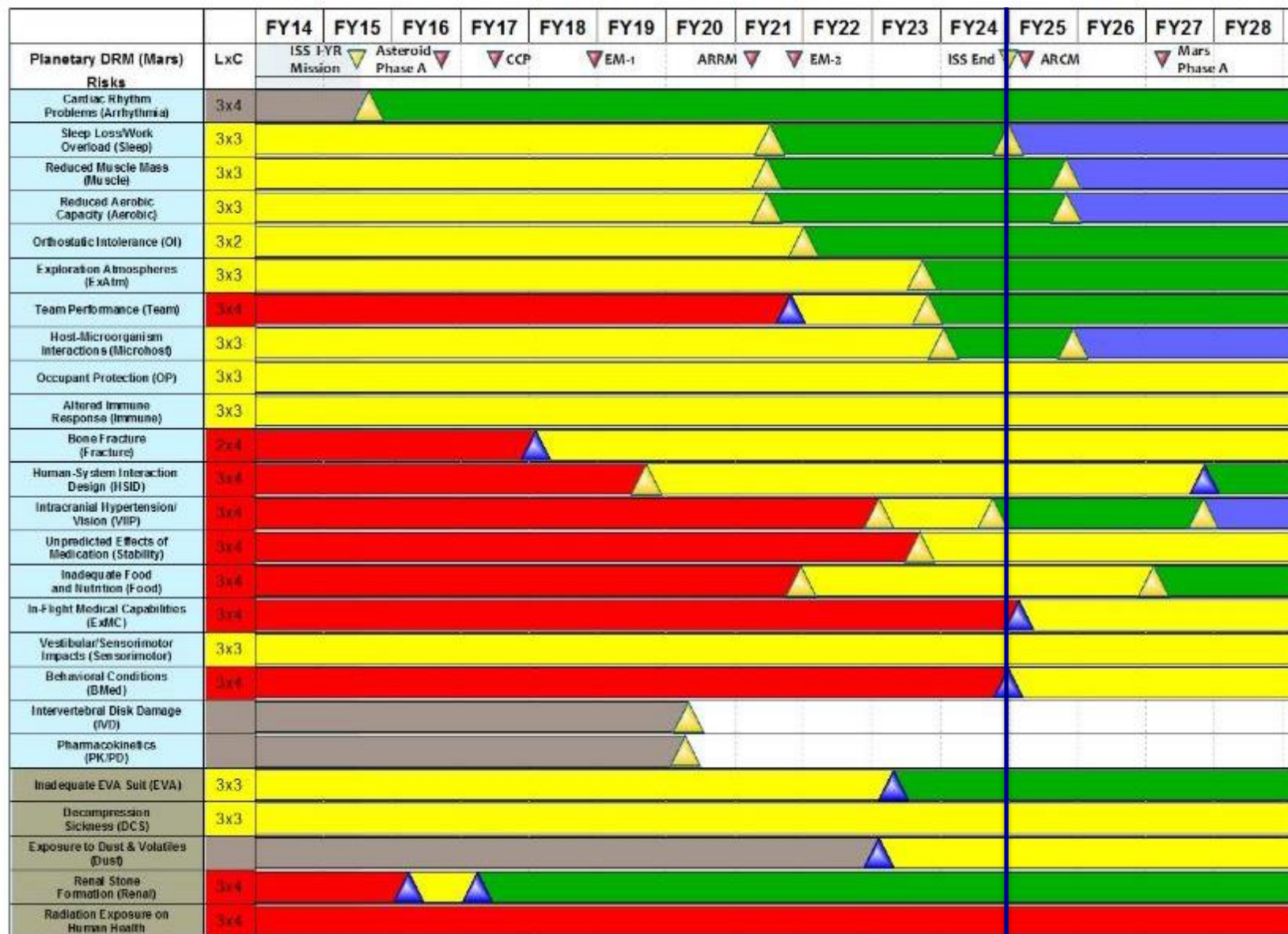


Habitation Systems Objectives



System	Includes	Today	Cis-Lunar Goal
Life Support	Air revitalization, water recovery, waste collection and processing	42% recovery of O ₂ from CO ₂ ; 90% recovery of H ₂ O; <6 mo MTBF for some components	>75% recovery of O ₂ from CO ₂ ; >98% recovery of H ₂ O; >2 yr MTBF
Environmental Monitoring	atmosphere, water, microbial, particulate, and acoustic monitors	Limited, crew-intensive on-board capability; rely on sample return to Earth	On-board analysis capability with no sample return; identify and quantify species and organisms in air & water
Crew Health	exercise equipment, medical treatment and diagnostic equipment, long-duration food storage	Large, cumbersome exercise equipment, limited on-orbit medical capability, food system based on frequent resupply	Small, effective exercise equipment, on-board medical capabilities, long-duration food system
EVA	Exploration suit	ISS EMU's based on Shuttle heritage technology; not extensible to surface ops	Next generation spacesuit with greater mobility, reliability, enhanced life support, operational flexibility
Fire	Non-toxic portable fire extinguisher, emergency mask, combustion products monitor, fire cleanup device	Large CO ₂ suppressant tanks, 2-cartridge mask, obsolete fire products. No fire cleanup other than depress/repress	Unified fire safety approach that works across small and large architecture elements
Radiation Protection	Low atomic number materials including polyethylene, water, or any hydrogen-containing materials	Node 2 CQ's augmented with polyethylene to reduce the impacts of trapped proton irradiation for ISS crew members	Solar particle event storm shelter based on optimized position of on-board materials and CQ's with minimized upmass to eliminate major impact of solar particle event on total mission dose

HRP Integrated Path to Risk Reduction



- Uncontrolled
- Partially Controlled
- Controlled
- Optimized
- Insufficient Data

Assumptions:

- 450 crew hrs/ Increment pair
- 3 crew/ Increment pair
- 6 month missions

Updated
6/10/15

ISS Required ISS Not Required



Milestones Requires ISS



Milestone Shift

Total = 25 risks require research

Exploration Systems Development

NASA Advisory Council
Meeting

November 4, 2015



SLS, Orion, and Ground Systems



Beginning human exploration beyond LEO as soon as practicable helps secure our future in space.

Orion
Crewed
Spacecraft



Space
Launch
System

Ground Systems
Development &
Operations



ESD EM-1 INTEGRATED MISSION MILESTONE SUMMARY

NASA ESD
Chart Updated: 09/10/2015, Rev C

ENTERPRISE

HEO / ESD

GSDO

Orion

SLS

ELEMENT LOCATION

Orion S/W

LAS

CM

ESA SM

ICPS

MSA/LVSA

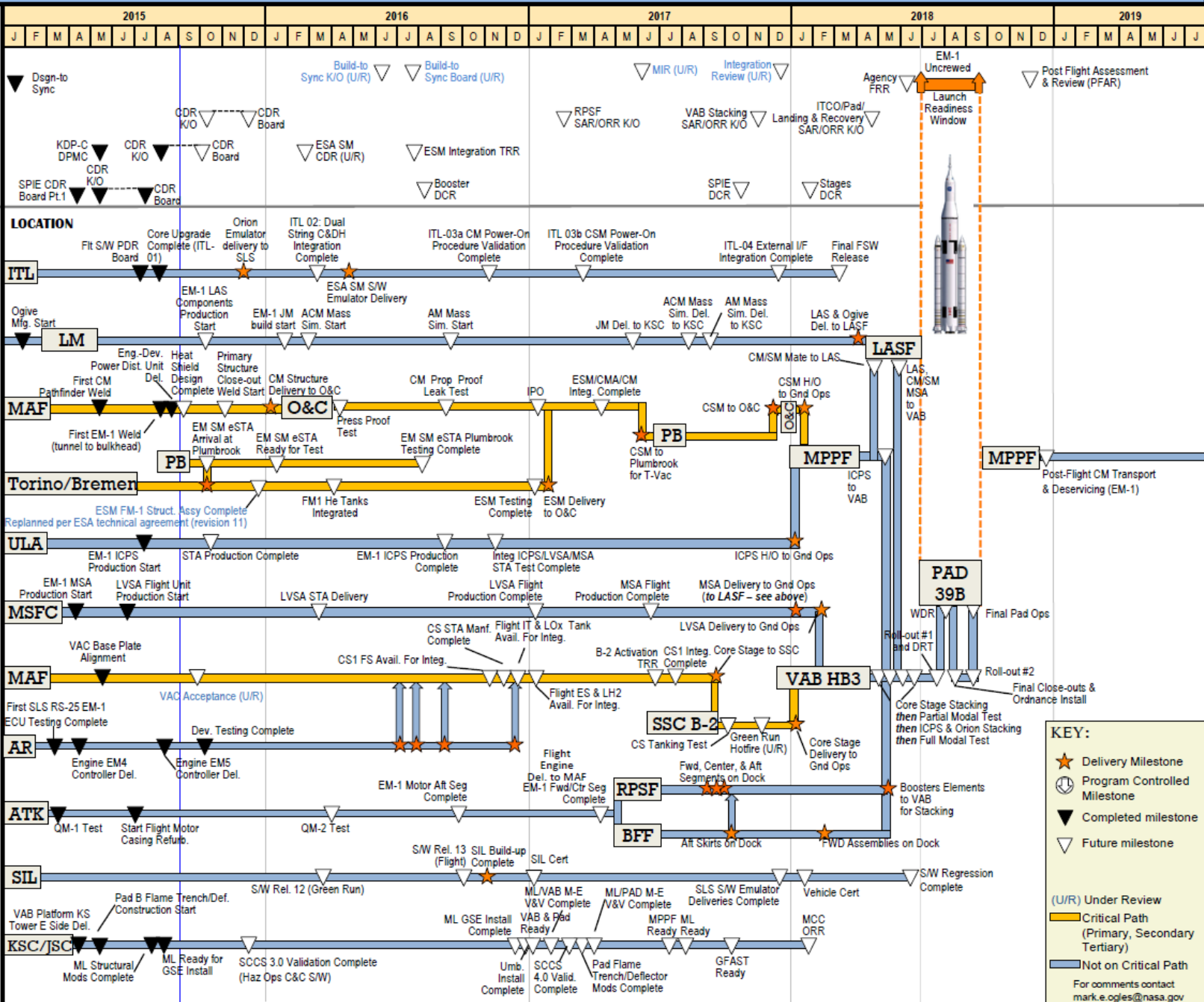
Core Stage

Engines

Boosters

SLS S/W

Ground



Orion Accomplishments



First weld of Orion Exploration Mission-1 crew module pressure vessel Michoud Assembly Facility



A manufacturing development unit of Orion's heat shield is being built at Lockheed Martin's facility in Denver



Pieces for the Orion spacecraft that will fly on EM-1 being prepared for welding at MAF



Orion's most challenging parachute drop test to date a success in August in Yuma, Arizona

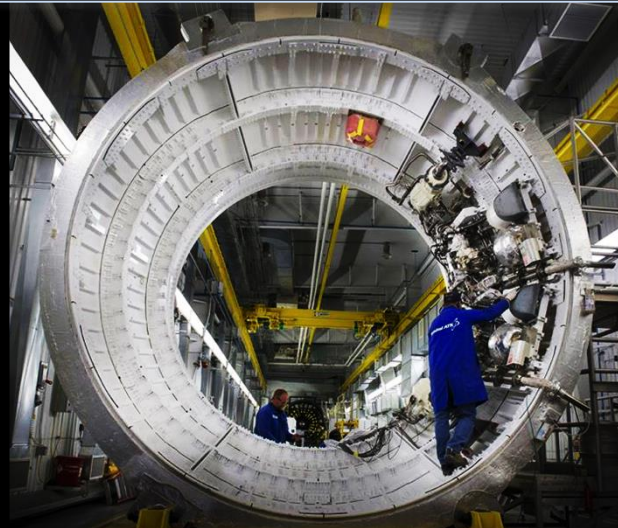


The Orion Crew Module Adapter simulator arrives at Plum Brook Station Space Power Facility in Sandusky, Ohio

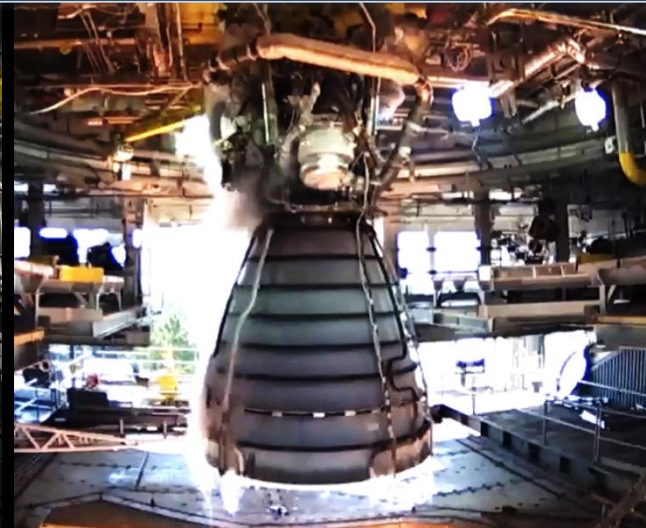
Space Launch System Accomplishments



Launch Vehicle Stage Adapter
Test Article fabrication



Booster Test Article in progress for
second qualification firing



RS-25 engine test conducted
at Stennis Space Center



Steel towers rising for new SLS test
stand at Marshall Space Flight Ctr.



SLS Core Stage hydrogen tank
progress, Michoud Assembly Facility



Pegasus barge completed, in
dock at Stennis Space Center

Ground Systems Development & Operations Accomplishments



Platform H is the newest platform to be delivered to the VAB at KSC



Simulation tests in Firing Room 4 at the Launch Control Complex at KSC



ICPS Umbilical arm guided into vertical position at the LETF at KSC



Ribbon cutting for Small Class Vehicle Launch Pad 39C

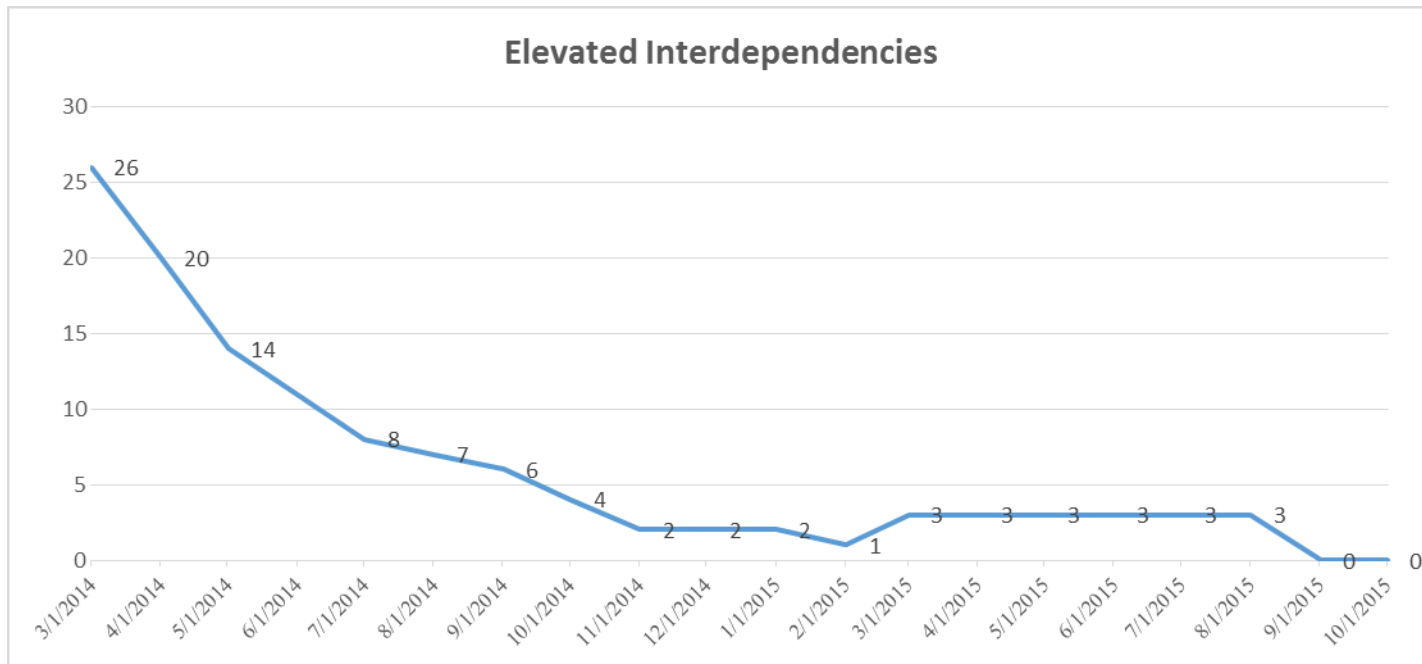


Modifications complete to Mobile Launcher base and tower structure at KSC

Elevated Interdependencies



No Elevated Interdependencies at this time



The team has managed Interdependencies through normal business processes and raised internally within Program management as needed to resolve minor issues



HEOMD's Advanced Exploration Systems

Status Update

Jason Crusan

Director, Advanced Exploration Systems Division

Human Exploration and Operations Mission Directorate

November 4, 2015



EARTH RELIANT

NEAR-TERM OBJECTIVES

DEVELOP AND VALIDATE EXPLORATION CAPABILITIES IN AN IN-SPACE ENVIRONMENT

- Long duration, deep space habitation systems
- Next generation space suit
- Autonomous operations
- Communications with increased delay
- Human and robotic mission operations
- Operations with reduced logistics capability
- Integrated exploration hardware testing

LONG-DURATION HUMAN HEALTH EVALUATION

- Evaluate mitigation techniques for crew health and performance in micro-g space environment
- Acclimation from zero-g to low-g

COMMERCIAL CREW TRANSPORTATION

- Acquire routine U.S. crew transportation to LEO



PROVING GROUND OBJECTIVES



Enabling Human Missions to Mars



TRANSPORTATION



WORKING IN SPACE



STAYING HEALTHY

- **Heavy Launch Capability**: beyond low-Earth orbit launch capabilities for crew, co-manifested payloads, large cargo
- **Crew**: transport at least four crew to cislunar space
- **In-Space Propulsion**: send crew and cargo on Mars-class mission durations and distances
- **ISRU**: Understand the nature and distribution of volatiles and extraction techniques and decide on their potential use in human exploration architecture.
- **Deep-space operations capabilities**: EVA, Staging, Logistics, Human-robotic integration, Autonomous operations
- **Science**: enable science community objectives
- **Deep-Space Habitation**: beyond low-Earth orbit habitation systems sufficient to support at least four crew on Mars-class mission durations and dormancy
- **Crew Health**: Validate crew health, performance and mitigation protocols for Mars-class missions

AES RECENT ACCOMPLISHMENTS



BEAM: Delivered flight hardware to KSC for launch on SpaceX-8 NET January 2016.



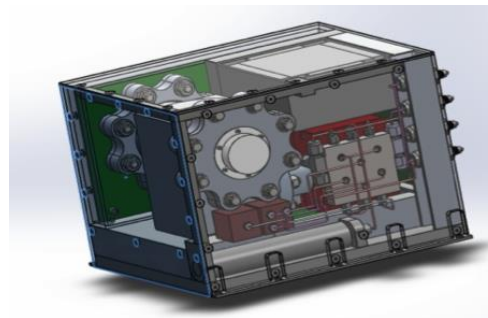
Logistics Reduction: Delivered Multi-Purpose Cargo Transfer Bag for demo on ISS. Bag will be repurposed to provide acoustic insulation of treadmill noise.



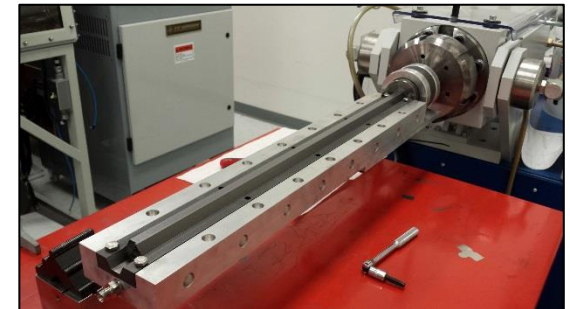
Spacecraft Fire Safety: Completed System Acceptance Review for the Saffire-I, II, and III flight experiments. Saffire-I will be launched on the Orb-5 mission in March 2016.



Resource Prospector: Completed field test of prototype rover and RESOLVE sample analysis payload in JSC rock yard.



Life Support Systems: Completed Systems Requirements Review for Spacecraft Atmosphere Monitor. ISS demo planned in 2018.



Nuclear Thermal Propulsion: Fabricated graphite composite fuel element and tested in 2800K hot hydrogen flow.



**CCP Status
to the
NASA Advisory Council
Human Exploration and Operations Committee**

**Kathryn Lueders
Manager
Commercial Crew Program**

November 5, 2015



Certification / CoFR Plan Overview



- **CTS Certification is the approval of the Commercial Provider's evidence that all tests/analyses/verification and validation proves that the baseline design meets the requirements (e.g. reference configuration)**
 - CTS Certification will be incrementally approved through Oversight and Risk Based Insight in parallel to CCtCap Certification related milestones (i.e. Uncrewed Flight Test DCR, Crewed Flight Test DCR, ORR, and CR)
 - To support this CTS Certification process, CCP SE&I will revise the existing Certification Plan (CCT-PLN-2000) to include the Certification endorsements and sub-endorsements
- **CTS CoFR refers to the NASA endorsement that compares and validates the hardware built and any issues uncovered to the reference certified configuration**
 - CTS CoFR will be incrementally approved through Oversight and Risk Based Insight in parallel to CCtCap Flight Readiness milestones: (i.e. Uncrewed Flight Test FTRR, Crewed Flight Test FTRR, and PCM FRRs)
 - To support this CTS CoFR process, CCP SE&I will create the CCP CoFR Plan (CCT-PLN-2100) to document the overall philosophy, roles and responsibilities and CoFR endorsements and sub-endorsements.



NASA CCP Certification



- **CCP Certification/CoFR strives to achieve a balance of insight/oversight appropriate for shared government & industry accountability in establishing a safe, reliable, and cost-effective CTS**
 - The **Industry Partner** is responsible for the design, development, test and evaluation; culminating in their certification assertion of its CTS to transport crew to and from the ISS.
 - **NASA CCP** is accountable for **ensuring compliance** to CCP's human spaceflight requirements thru **evaluation and approval** of the Contractor's compliance evidence and execution of **NASA's insight** into the Contractor's solution in accordance with a risk based insight approach implemented under a shared assurance model.



CCP Requirement Development



NPR 8705.2B Allocation to CCTS

- **Agency, HEOMD, and Program retain key accountability for NASA Human Spaceflight safety and mission success requirements allocated from NPR 8705.2B within overall NASA and industry shared accountability structure**
 - NPR 8705.2B was used as a basis in developing the HEOMD-10001 document, with applicable requirements flowed down to CCP Requirements documents, which have been levied on the CCtCap contract
 - The Human Rating Certification Package in NPR 8705.2B Appendix D represents a sub-set of the data required in the CCTS Certification Data Package defined in HEOMD-10001



- **CCT-REQ-1130 requirement are the requirement set for the entire CTS from launch through landing while independent of ISS**
- **SSP 50808 is an over-arching Interface Requirements Document for ISS**
 - Covers CRS and Commercial Crew
 - Contains requirements that are necessary for the docking or berthing to the ISS
 - Contains requirements governing the visiting vehicle within the 4 x 2 x 2 km approach ellipsoid around ISS
 - Contains requirements for the vehicle as docked to ISS
 - Day to day living and activities as part of station
- **Standards**
 - All standards for both documents have been reviewed and are the same or complimentary.
 - An example of complimentary are the two fracture control standards. One is for the broad scope of the system and the other is ISS specific:
 - NASA-STD-5019 for system fracture control
 - SSP 30558 for ISS specific fracture control
- **Variances**
 - Variances can be submitted for both CCT-REQ-1130 and SSP 50808 requirements
 - All variances will be reviewed and approved through the appropriate Program Board structure
- **Requests for variances to SSP 50808 processed in accordance with ISSP Board Structure**
- **ISS Integration is based on successful visiting vehicle integration both with International Partners and Commercial Resupply Services (CRS)**



CCT-REQ-1130



Purpose and Mapping

• CCT-REQ-1130 contains:

- Performance requirements in meeting the ISS DRM documented in CCT-PLN-1110
- Human rating requirements allocated from NPR 8705.2B (trace shown below)

NPR 8705.2B Human-Rating Technical Requirements (Chapter 3)		→ Maps to HEOMD-10001 Requirement	→ Allocated to CCT-REQ-1130 Requirement	
Key	Title	Key	Key	Title
3.2.1	Crew Environment	5.2.1	3.10 (and subs)	Human Health, Medical and Performance
			3.2.5.11	Pressure Suits
3.2.2	Probabilistic Safety Criteria	5.2.2	3.2.1.1	Loss of Crew Risk
			3.2.1.2	Loss of Mission Risk
3.2.3	Failure Tolerance	5.2.3	3.2.3.1	Failure Tolerance to Catastrophic Events
				Separation of Redundant Systems
3.2.4	Failure Tolerance without Emergency Equipment	5.2.4	3.2.3.2	Failure Tolerance without Aborts
3.2.5	Tolerate Inadvertent Operator Action	5.2.5	3.8.5.1.2	Tolerate Inadvertent Action
3.2.6	Tolerate Inadvertent Operator Action during Failure	5.2.6	3.8.5.1.4	Tolerate Inadvertent Action during Failure
3.2.7	Critical Software Control Detect and Annunciate	5.2.7	3.9.2.1	Software Engineering Requirements
3.2.8	Faults	5.2.8	3.2.4.1	Detect and Annunciate Faults

NPR 8705.2B Human-Rating Technical Requirements (Chapter 3)		→ Maps to HEOMD-10001 Requirement	→ Allocated to CCT-REQ-1130 Requirement	
Key	Title	Key	Key	Title
3.2.9	Isolate and Recover from Faults	5.2.9	3.2.3.4	Isolate and Recover from Faults
3.2.10	Health and Status Data	5.2.10	3.2.4.2	Record and Display Health and Status
3.2.11	Autonomous Operation of System	5.2.11	3.2.6.3	Autonomous Operation of System
3.2.12	Access Emergency Equipment	5.2.12	3.2.5.1	Access Emergency Equipment
3.3.1	Crew Control of Vehicle	5.3.1	3.8.5.1.1	Crew Control of Vehicle
3.3.2	Manually Override Software	5.3.2	3.2.6.1	Manually Override Software
			3.2.6.2	Manually Override Software - Post-Separation
3.3.3	Ground Monitoring and Operation	5.3.3	3.7.1	Ground Monitoring and Operation
3.4.1	Manual Control of Vehicle Flight Path	5.4.1	3.8.4.1	Manual Control of Vehicle Flight Path
			3.8.4.2	Manual Piloting for Docking
3.4.2	Handling Qualities	5.4.2	3.8.4.3	Handling Qualities

(Remaining trace in backup)



Commercial Crew Summary



- **CCP**

- Continues to work with both Providers on maturing their designs
- Establishing the NASA expectations for both the CCP Certification Plan and Certification of Flight Readiness Plans

- **Both Providers**

- Are meeting contractual milestones
- Are progressing through the Phase II Safety Reviews
- Are working detailed Verification and Validation planning
- Are maturing their detailed designs
- Are providing increased insight opportunities for the NASA team
- Have advanced beyond paper products and are building and testing hardware

- **They, and we, have a great deal of work in front of us.**



- Plan for Commercial Crew vehicle certification and flight readiness seems reasonable – critical work and process definition ahead
- Capability requirements for future exploration being used to guide ISS transition
 - Progress on ISS transition plans – work still under way
- SLS, Orion, and ground systems – building momentum
- Current capability based approach for human exploration is reasonable considering current political and economic environment

- Lack of US launched crew transportation to Low Earth Orbit
- Interruption in US launched cargo capability
- Current level of definition for Mars exploration architecture impedes effort to generate support.
- Cost impact of NASA processes are a threat to accomplishment of NASA's exploration mission
- Low SLS and Orion Launch rate pose future risks for proficiency of the operations team and reduce program resilience in the event of mission failure

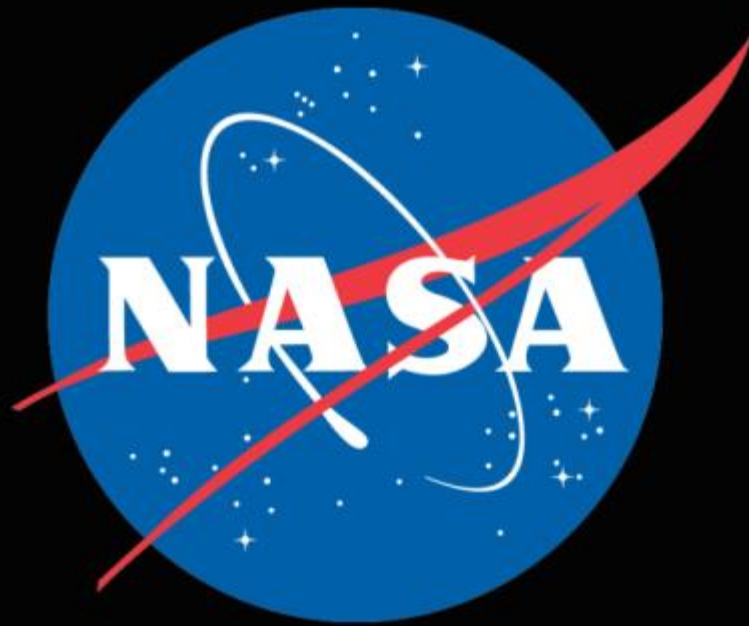


Future Special Topics:

- International Participation in Future Human Exploration
- ISS uses for Exploration development
- ISS transition after 2024
- Exploration plans after ARM
- Plans for Transition of Administration

Items for Continued Review

- NASA Management Processes
- Certification of readiness process for commercial crew
- Integration and Standardization



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